AIR POLLUTION AND HEALTH

MEDICAL EVIDENCE SUMMARY

Clay Ballantine, M.D.

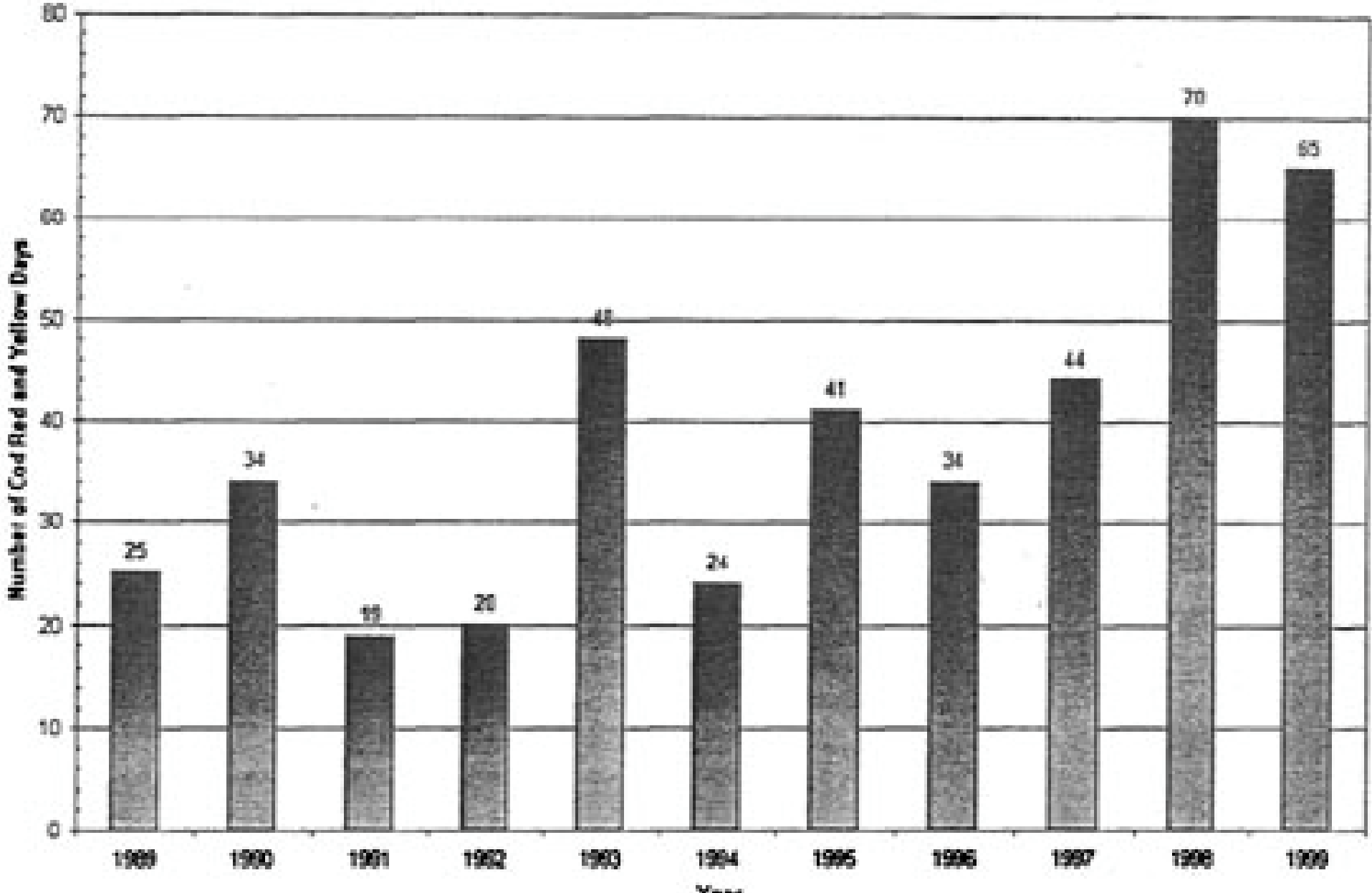
Medical Studies

- Peer-reviewed journals
- Thousands of studies
- Physiology
- Epidemiology
- Government databases
- Dose-Response relationship

Causes of Death in U.S.

1. Cardiovascular Disease
2. Cancer
3. Lung Disease

Figure 1. Unhealthy Air Days in North Carolina



NC Medical Society Resolution

2001 House of Delegates unanimously adopted a resolution sponsored by the Buncombe Co. Medical Society, urging all branches of state government to work toward cleaner air because of the large public health impact of air pollution exposure.

4 Main Pollutants

- Ozone
- Particulates, especially PM 2.5
- Air-borne toxics
- Mercury

RISK

Assumed vs. Imposed

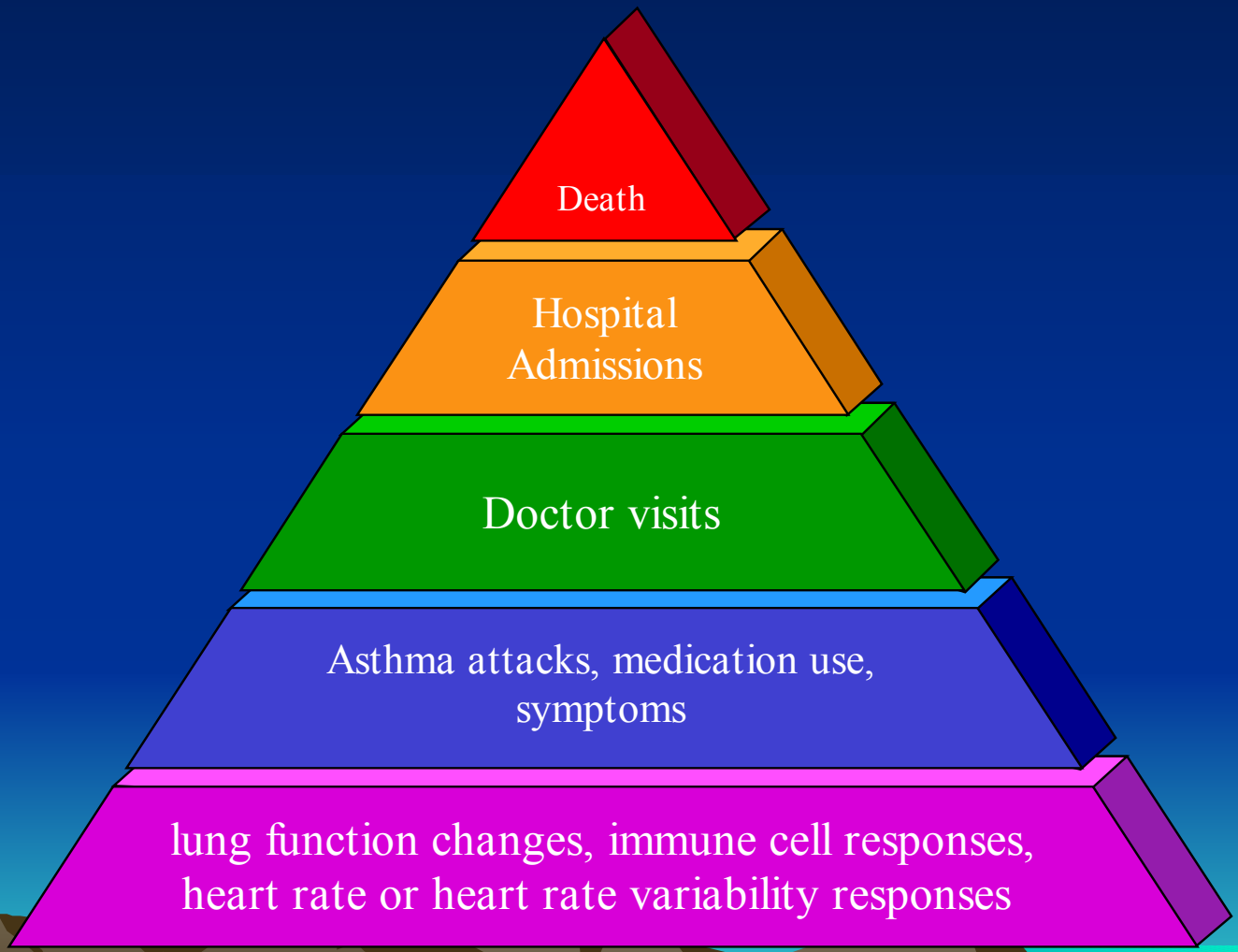
Who is at Risk?

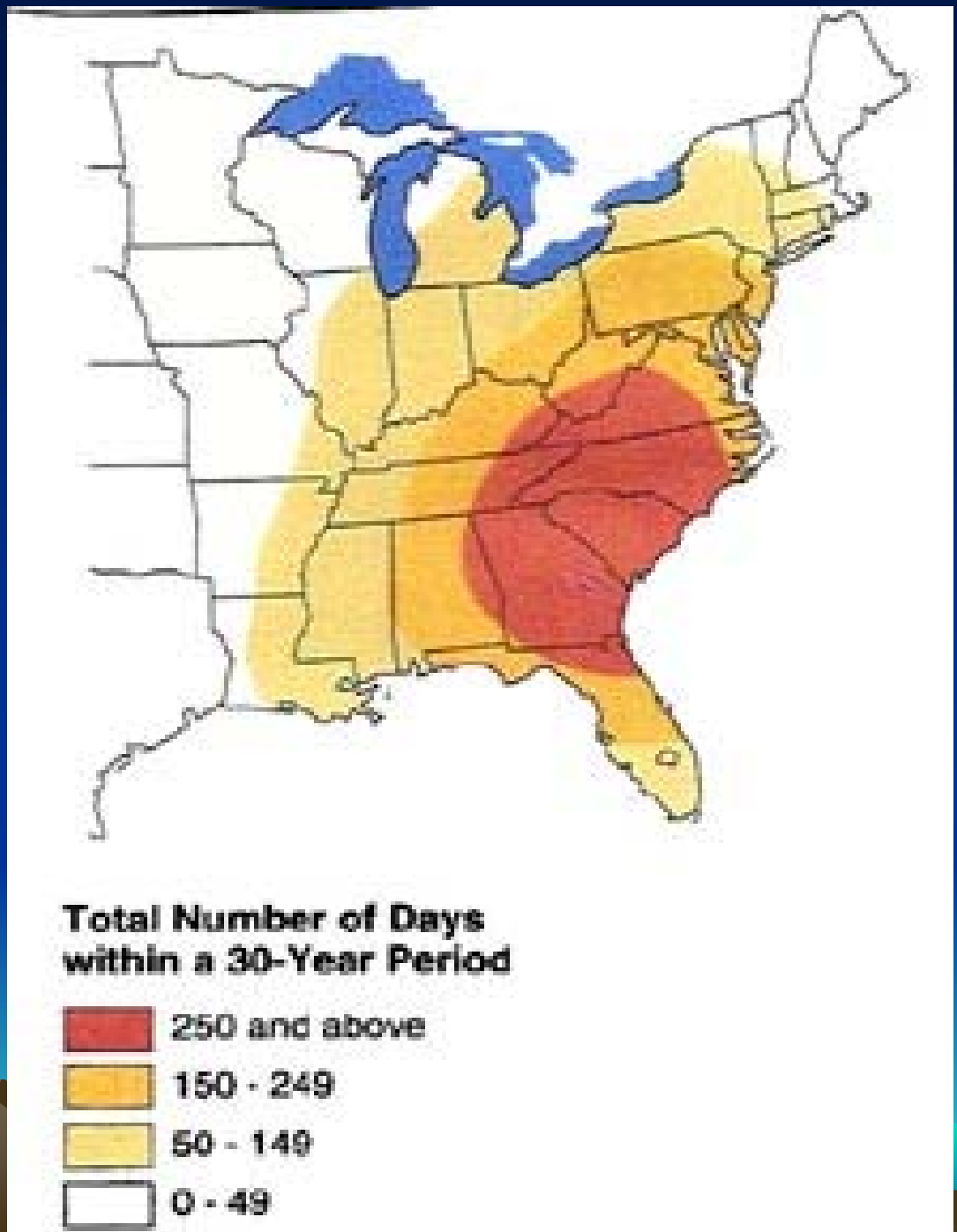
- Children
- Elderly
- Prior heart or lung disease patients
- Diabetics
- Persons who work/exercise outdoors
- Otherwise healthy adults and children

Health Problems

- Impaired fertility
- Birth Defects
- Respiratory Infections
- Asthma
- Emphysema
- Lung Cancer
- Heart attacks
- Strokes
- Premature Death

“Pyramid of Effects”




Total Number of Days
within a 30-Year Period
250 and above
150 - 249
50 - 149
0 - 49

Air Pollutants: Ground Level Ozone

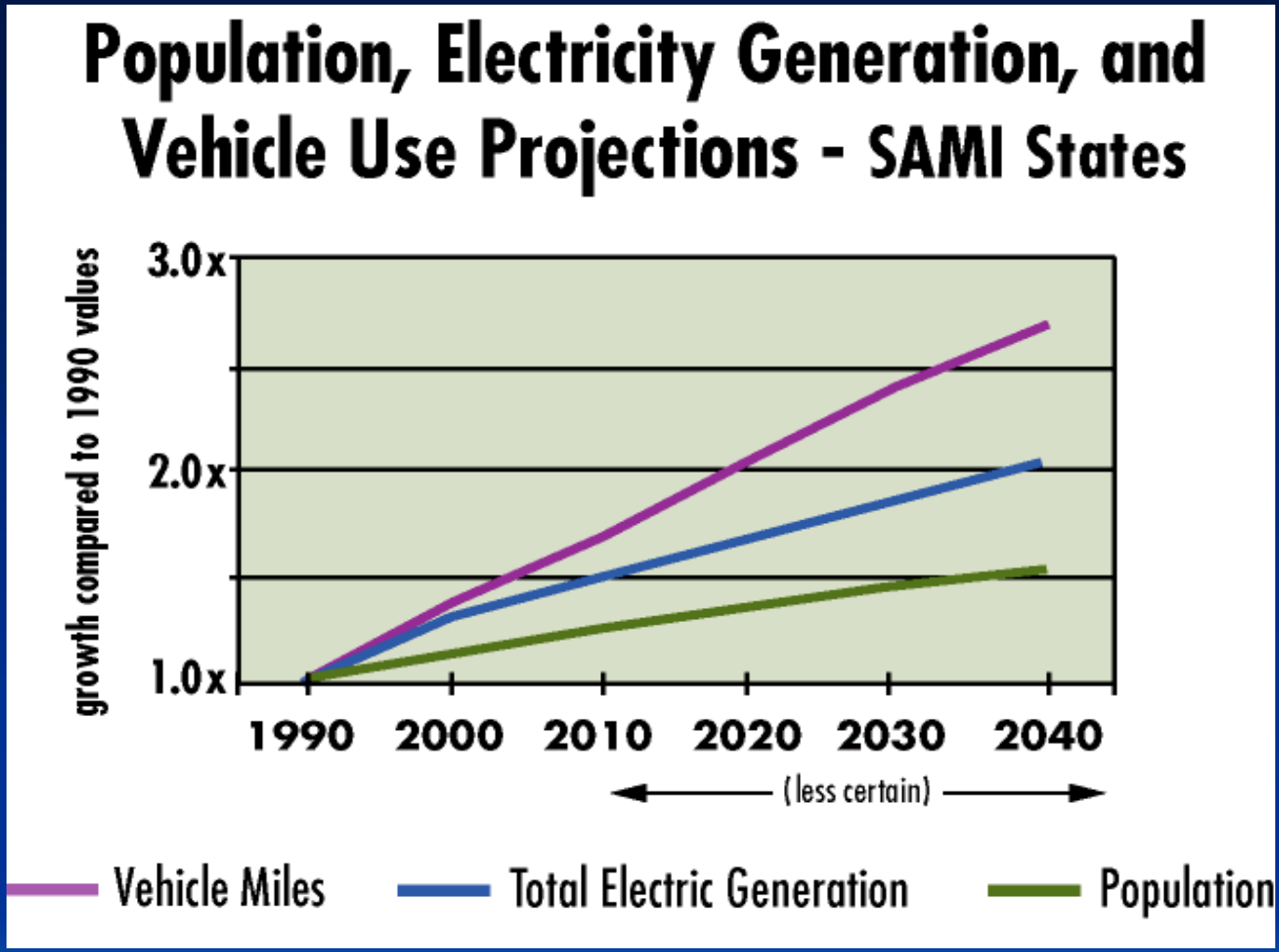
Ultra-violet light

Volatile organics

Nitrogen oxides

Air Pollutants: Ground Level Ozone

50% nitrogen oxides from traffic



By 2010 vehicle use will grow 70% and electricity use 50%.

By 2040 vehicle use will grow 170% and electricity 100%.

Air Pollutants: Ground Level Ozone

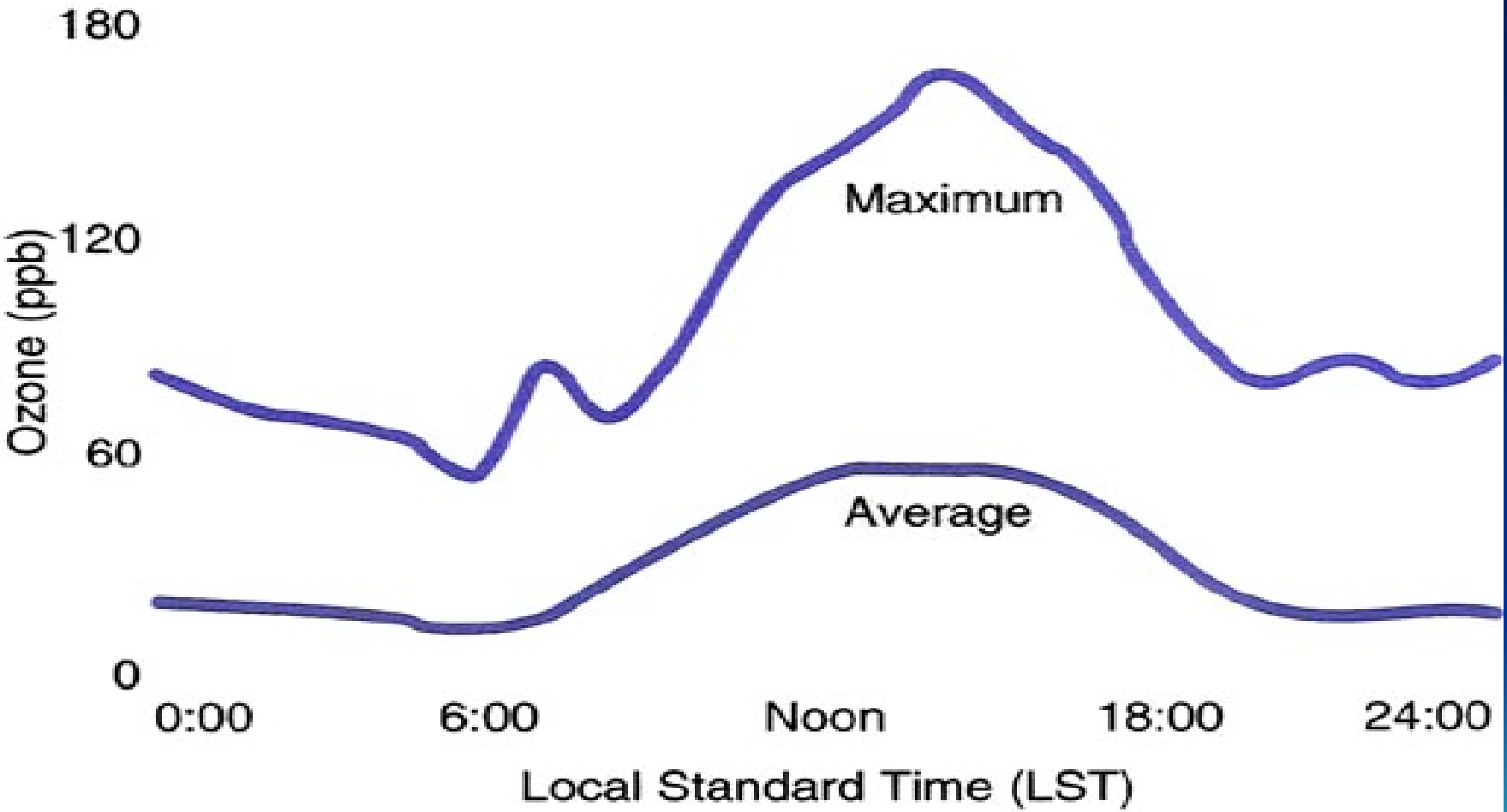
Seasonal variation

Daily variation

Outdoors

Does not penetrate buildings

Figure 12.10. Typical Ozone Concentrations by Time of Day



Source: U.S. Environmental Protection Agency. Data reflect all observations recorded at the Plaza Rd. site in Charlotte, 1981-89.

Ozone's physiology

- Caustic gas--clear , colorless, odorless
- Oxidizes proteins and lipids in the mucosal fluid layer
- Highly irritating to lung linings
- Increases lung secretions, decreases oxygenation
- Sets off airway bronchospasm
- Recruits inflammatory cells
- Increases responses to allergens
- Damages infection fighting responses
- Chronic lung damage/remodeling

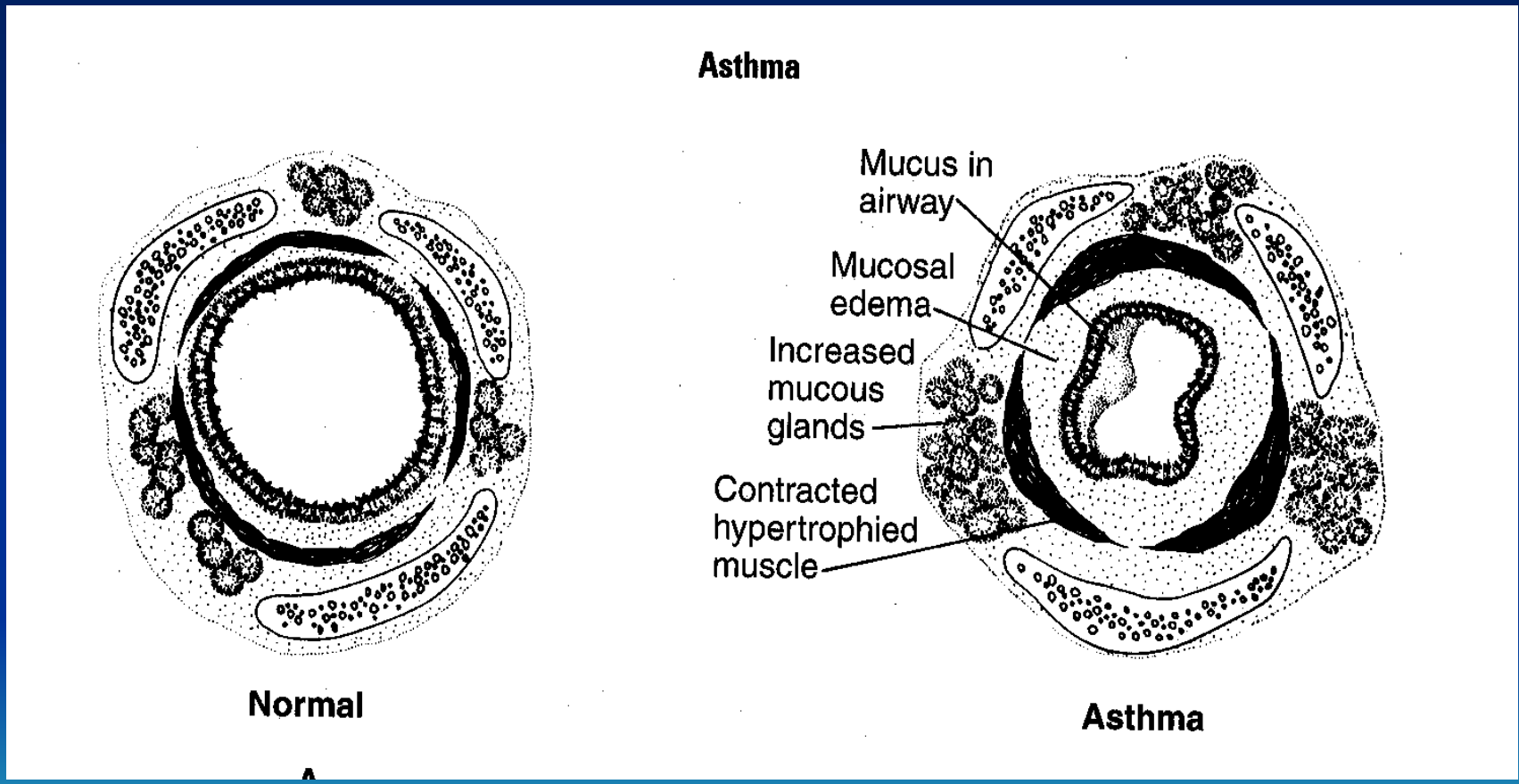
Ozone and Asthma Attacks

Hundreds of published studies from around the world all show the same results:

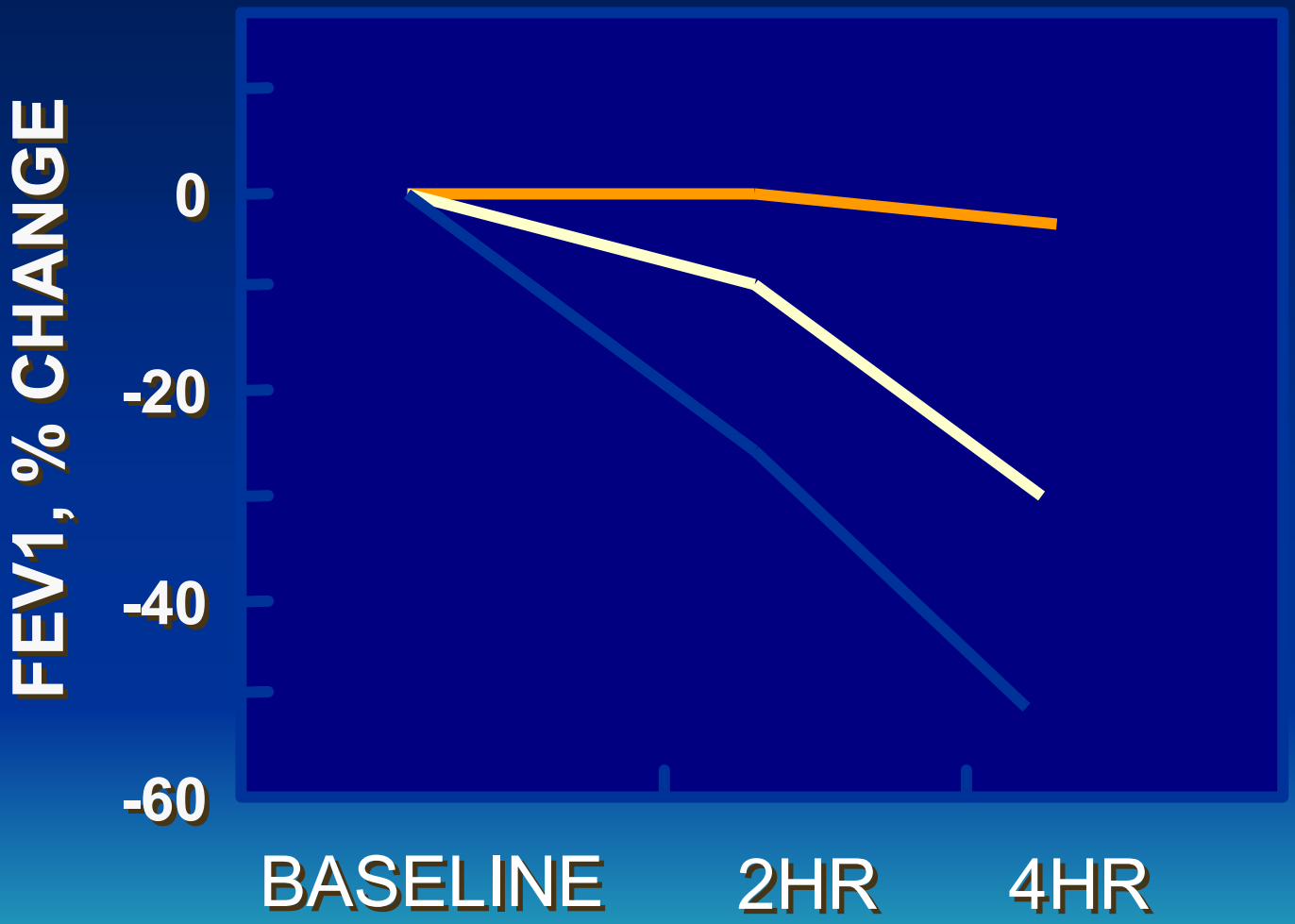
More ozone pollution exposure leads to more asthma attacks.

Dose = Response relationship

Airway Obstruction



Ozone Reduces Lung Function



Asthma and Air Pollution

Epidemiologic analysis of air quality data from 1997 and asthma rates showed:

One third to one half of asthma attacks in North Carolina annually are due to air pollution exposure

Abt Associates report, 1999

North Carolina Summers

Air pollution causes an EXTRA:

240,000 Asthma Attacks
6,300 ER Visits
1,900 Admissions

(Abt Associates, 1999)

Ozone Causes Asthma

Exercising children exposed to ozone: a cohort study

↑ time outdoors = ↑ asthma

McConnell, et al. Lancet 2002: 359: 386-91

Ozone: Asthma Effects

- More people with asthma
- More asthma attacks
- More asthma medicine use
- More doctor, ER and Urgent Care visits
- More children and elderly in hospitals
- More school absences
- More lost work days

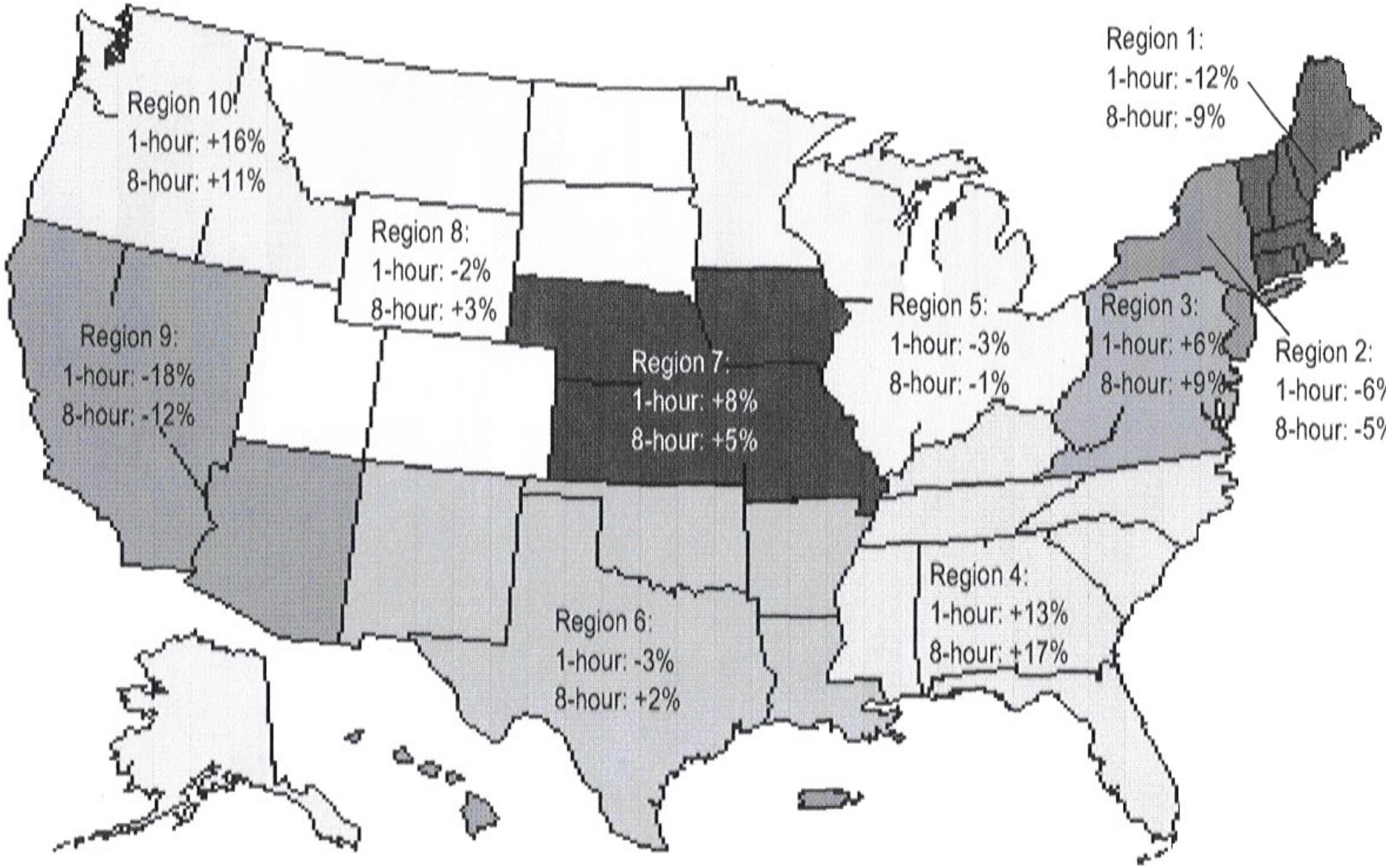
Ozone: Other Effects

- ↑ allergy symptoms
- ↑ respiratory infections
- ↑ ear infections
- ↑ emphysema attacks
- ↑ overall death rates

Ozone Pollution Health Risks
The ALA "Worst 25"

Atlanta	6th
Knoxville	8th
Charlotte	9th
Raleigh-Durham	13th
Nashville	18th
Memphis	19th
New York	20th
Birmingham	21st
Greensboro-Winston	21st
Macon	24th
Chattanooga	24th

Figure 7: Trends in the 2nd Highest Daily 1-Hour and 4th Highest Daily 8-Hour Ozone Concentration by EPA Region, 1989-1998



Source: EPA, National Air Quality and Emissions Trend Report, 1998

Air Pollutants: Particulates

Year round exposures

Penetrate buildings

Air Pollutants: Particulates

Sulfates, nitrates,

Polycyclic Aromatic Hydrocarbons (PAH),

Soot / Carbon

and Dust

Particulate Components

34 Elemental Metals

Sulfur oxides, nitrogen oxides, ammonia

9 Light PAHs

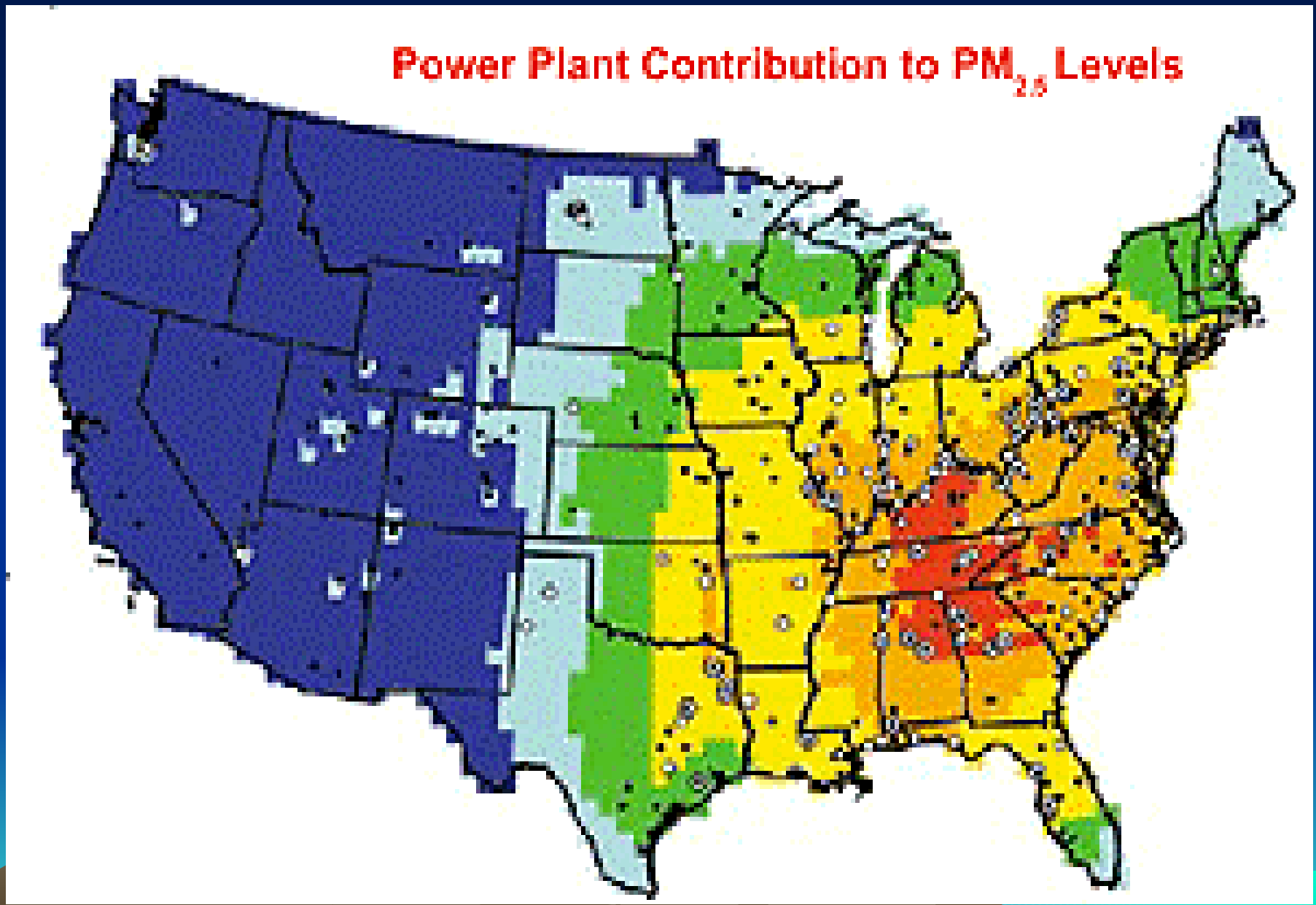
14 Heavy PAHs

Bio-organics

Traffic tracers: 2 Hopanes

4 Steranes

Particulate Pollution



Sulfate Emission Increases

Table 3: "Sooty Seven" States with Highest Increases in SO2 Emissions between 1995 and 2000			
State	1995 SO2	2000 SO2	Total Increase 1995-2000
North Carolina	392,200	453,391	61,191
New York	192,803	244,431	51,628
Mississippi	83,703	129,892	46,189
Georgia	472,779	508,336	35,557
Washington	52,941	83,604	30,663
South Carolina	177,854	200,252	22,398
Maryland	226,971	248,799	21,828

Particulate Physiology

- Penetrate deeply into lungs to alveoli
- Irritate lung linings-more asthma
- Stimulate immune system inflammatory proteins

Sudden Cardiac Deaths

- Leading cause of death in US
  - 350,000 deaths per year
  - Approximately 50% of cardiovascular deaths
- Often first sign of heart disease
- Ventricular arrhythmias most common causal pathway
  - Ventricular tachycardia
  - Ventricular fibrillation

Particulates: Cardiac Effects

- ↑ Vascular inflammation
- ↑ Blood clotting protein levels
- ↑ Cardiac arrhythmias
- ↑ Blood pressure
- ↑ Heart rate variability

Alters cardiac conduction

Air Pollution and Next-Day Heart Attacks

- Short term exposure to particulates (PM2.5) increases the incidence of heart attacks for one day following exposure

- As air pollution goes up the risk of heart attack goes up

Increased Particulate Air Pollution and the Triggering of Myocardial Infarction Peters, et al.; Circulation, June 12, 2001, vol. 103

Traffic Emissions and Death

Compared two groups:

People living near a main road and those farther from traffic-related particulates and diesel exhaust.

Hoek, G., et al. "Association between Mortality and Indicators of Traffic-related Air Pollution in the Netherlands: A Cohort Study" Lancet 360 (2002) 1203

Traffic Emissions and Death

Near-road group had:

- **Almost double the death rate from heart and lung disease**
- **1.4 times higher overall death rate**

Hoek, G., et al. "Association between Mortality and Indicators of Traffic-related Air Pollution in the Netherlands: A Cohort Study"

Lancet 360 (2002) 1203

Tunnel Workers Particulate Exposure Study

Swedish automobile tunnel workers

Higher incidences of cardiac events (heart attacks and deaths)

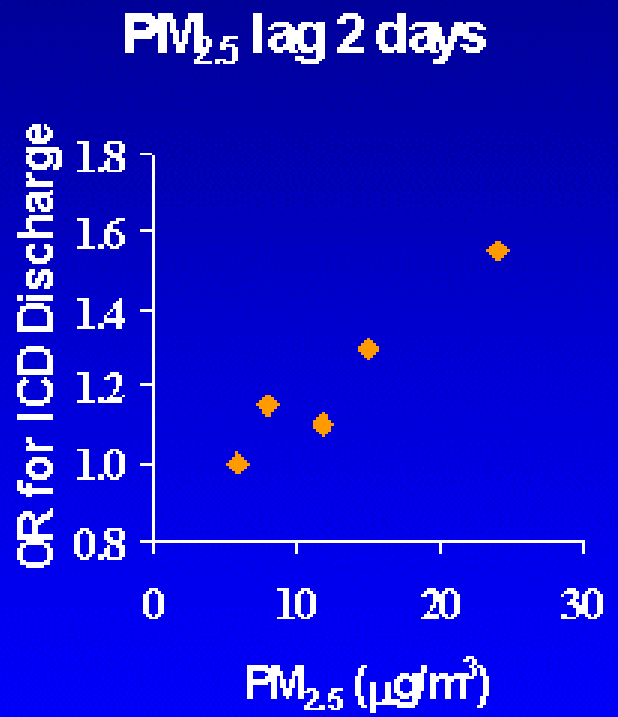
due to exposure to particulates at tunnel work stations

Bellander, T.,Dept. of Environmental Health, Sweden, WHO/HEI Conference March, 2001

Air Pollution and Incidence of Cardiac Arrhythmias

Peters et al, Epidemiology 2000

- OR for ICD Discharge associated with $PM_{2.5}$, Black Carbon, and NO_2
- Stronger associations among 6 patients with 10+ events (effect of 5%-95% air pollution)
  - $PM_{2.5}$ 1.22 (0.7,2.0)
  - BC 2.16 (1.0,4.9)
  - NO_2 3.13 (1.8,5.6)



Lung Cancer, Cardiopulmonary Mortality, and Long-term Exposure to Fine Particulate Air Pollution

- American Cancer Society's Cancer Prevention II study
- 1.2 million adults enrolled in 1982
- 500,000 adults matched to available air pollution data in U.S.
- Extensive risk factor questionnaires

Pope, et al. JAMA 2002 ;287:1132-1141

Lung Cancer… (Pope, et al)

For every increase in particulate exposure of 10 mcg/m^3, there was increased risk of:

- 4% All cause mortality
- 6% Cardiopulmonary mortality
- 8% Lung cancer mortality

Pope, et al. JAMA 2002 ;287:1132-1141

Lung Cancer… (Pope, et al)

Risk increase:

Same as living with a smoker (second-hand smoke exposure)

Pope, et al. JAMA 2002 ;287:1132-1141

Air Pollution and Stroke Deaths

- Fine particulate matter and gaseous pollutants are significant risk factors for acute stroke death
- Women and the elderly are most susceptible to the effects of particulate air pollutants
- More air pollution exposure=more acute stroke deaths

Effect of Air Pollutants on Acute Stroke Mortality. Hong, et al.

Feb., 2002; Environmental Health Perspectives, v. 110. no.2

Two Different Immune System Responses

- Th1 = Normal infection fighting response
- Th2 = Allergic/Asthmatic response

Diesel Exhaust Permanently Changes Immune Response

- More Asthmatic and Allergic responses
- Increases Th2
- Decreases Th1
- Polycyclic aromatic hydrocarbons (PAH) are the culprits
- Diesel and vehicle exhaust and coal smoke

Nel, A.E., et al., J of Allergy and Clinical Immunology, 2001

Particulates and Asthma

- Multiple studies show direct correlation between exposure to particulates and increases in asthma attacks and hospitalization rates
- Effects seen in adults and especially pronounced in children

PAH and Allergies

PAH exposure increases the physiological responses to allergens

Allergy symptoms scores worse 3-fold

Diaz-Sanchez J. All. Clin. Immun. Dec 2000 106

Long-term Effects of Particulate Pollution Exposure

Up to 4% of all US deaths

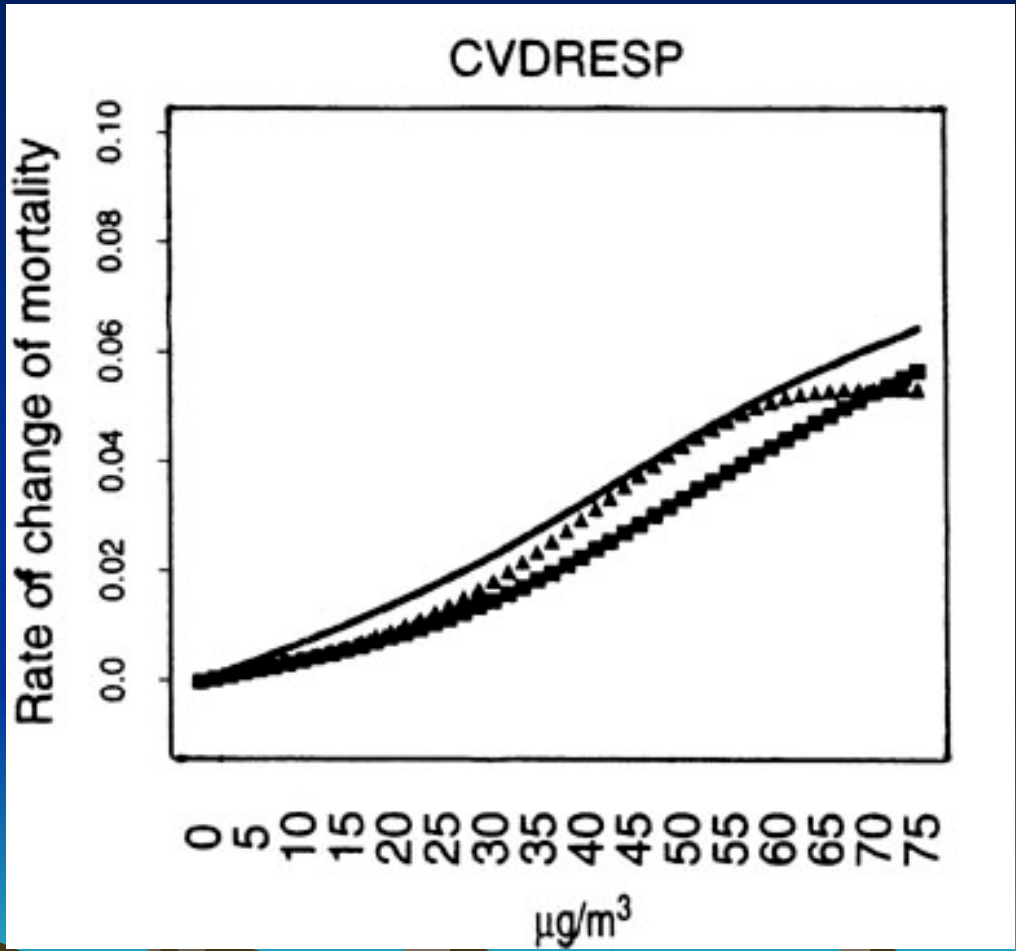
1 to 3 year drop in life expectancy

(smokers lose ~4 years)

5% of all cardiac hospitalizations

Effects on healthy people as well

Lack of Threshold Effect: Nowhere to hide



Daniels et al "NMMAPS" Am J Epidemiology v.152, no. 5. (2000)

Area Cities at Risk >15 mcg/m^3 PM 2.5 Weighted Annual Mean

- Asheville = 15.1
- Charlotte = 17.2
- Raleigh = 16.5
- Greensboro = 17.8
- Atlanta = 21.4
- Greenville, SC = 16.5
- Johnson City, TN = 16.4

EPA data 2000

WNC Health

- Lowest overall mortality in state
- Lower lung cancer death rates
- (low cigarette use)
- Higher mortality from lung diseases pneumonia and emphysema
- Higher levels of fine particulate and air toxics air pollution than state or US

NC State Center for Health Statistics, 1998

Effects on Otherwise Healthy People

- ↑ Asthma rates in adults
- ↑ Pneumonia and respiratory infections
- ↑ Lung cancer rates similar to living with a smoker
- ↑ Overall death rates

Faster decline in lung function with age

Effects on Children
--A Generation at Risk--

- Multiple birth defects-heart, neural tube
- Higher infant mortality
- More asthma
- Impaired lung development
- Premature emphysema
- Increased respiratory infections
- Higher health care expenditures

Childhood asthma

Increased by 55% from 1982-1996

#1 cause of hospitalization (< 18 yrs)

#1 health care cost for childhood diseases

#1 cause lost school days (chronic illness)

1/2 to 1/3 of NC asthma due to air pollution

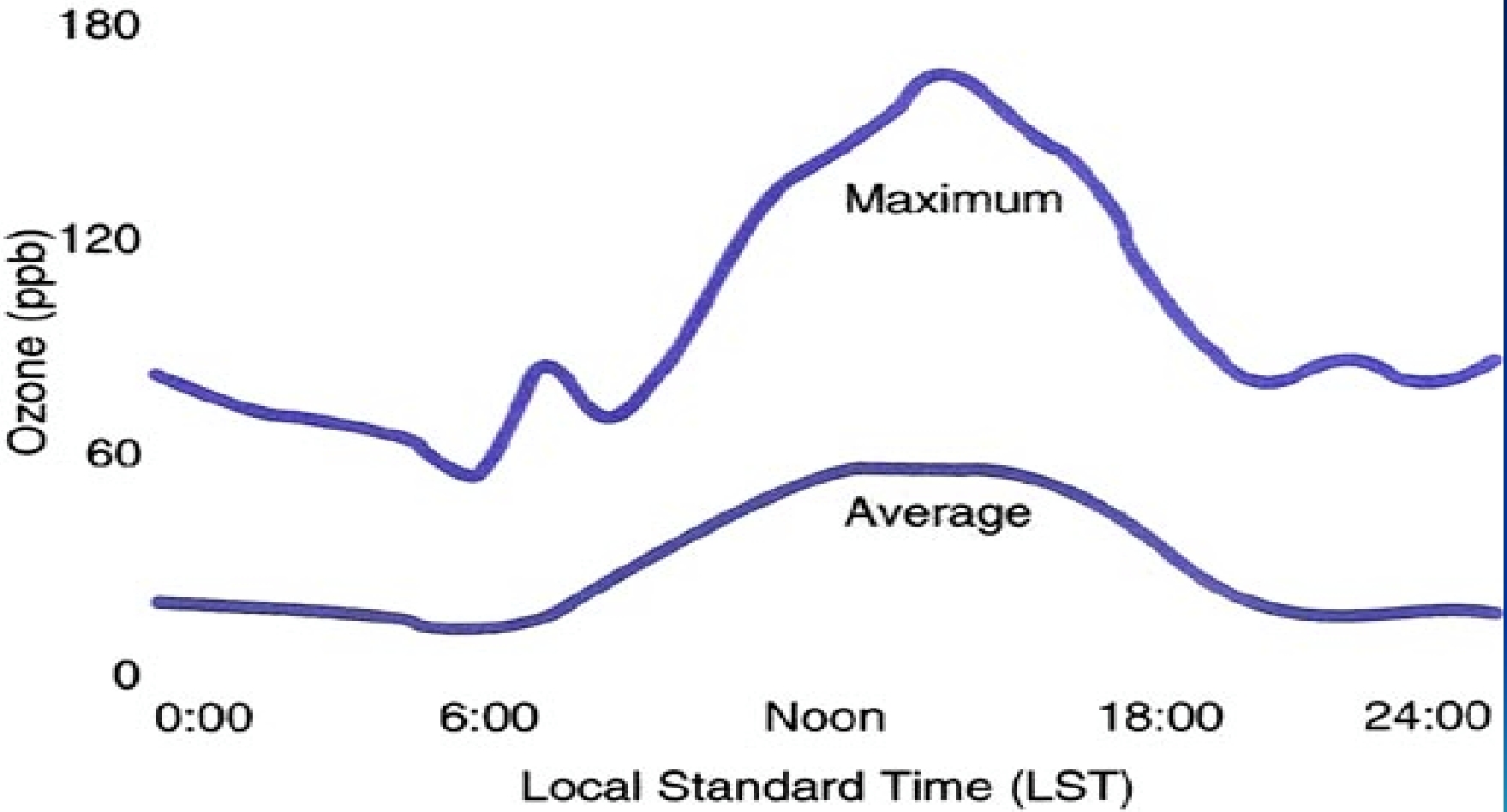
Asthma in Buncombe County

10%	Children diagnosed with asthma
25-30%	Asthma symptoms

Similar results in all North Carolina counties

NC Dept. HHS-Div. Of Public Health, 2001

Figure 12.10. Typical Ozone Concentrations by Time of Day



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McConnell, et al. Lancet 2002: 359: 386-91

Air Pollution and Lung Function Growth

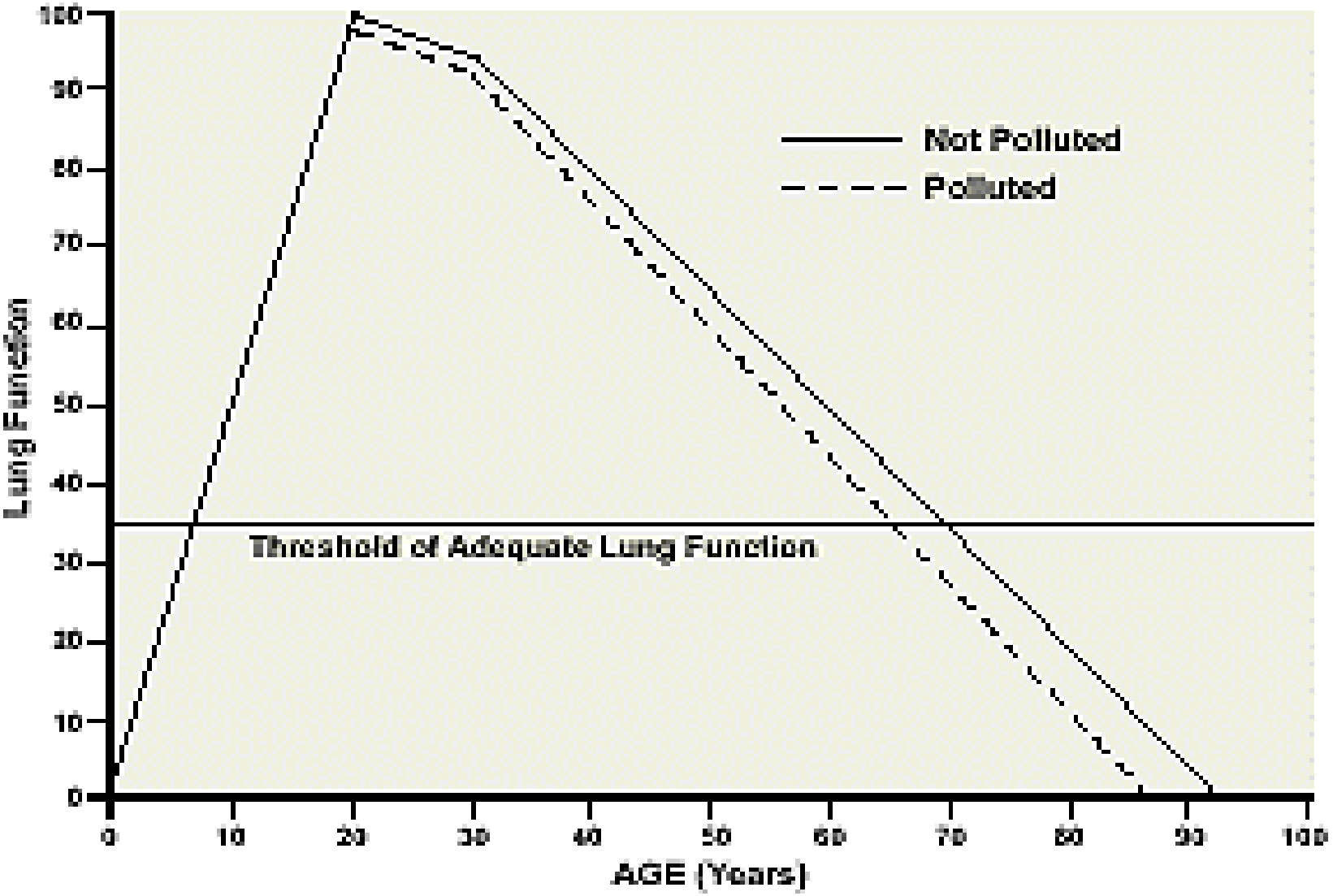
1700 4th graders followed for 4 years

10% lower lung function for children growing up in more polluted air

Most time in polluted air = worst impairment of lung growth

Association between Air Pollution and Lung Function Growth in Southern California Children. Gauderman, W., et al., Am J Respiratory and Critical Care Medicine, vol.166 (2002) pp.76-84.

Schematic of Lung Function vs. Age Showing Loss of Life Expectancy



Results of Clean-up

- During 1996 Summer Olympics, reduced ozone levels due to transit system changes led to a significant drop in children's asthma.
- After German reunification, pollution dropped and children's respiratory symptoms decreased dramatically.

Friedman, M.S., et al. JAMA, V. 285, No. 7, 2001

Heinrich, J., et al., Am. J. Resp. and Crit. Care Med., V.161, 2000

Air Pollution and Medical Care Costs

- Millions of Medicare records for
  183 U.S. Cities (patient ages 65-84)
- Analyzed for Medicare costs and air pollution exposure levels, city by city
- Controlled for other illnesses, smoking, and economic status

Air Pollution and Medical Care Use by Older Americans: A Cross Area Analysis. Fuchs, Victor and Rosen, Sarah

Health Affairs, vol. 21, no. 26 pp207-214

Air Pollution and Medical Care Costs

Every 10 ppb particulates=

$177 extra cost to Medicare per patient per year

Air Pollution and Medical Care Use by Older Americans: A Cross Area Analysis. Fuchs, Victor and Rosen, Sarah

Health Affairs, vol. 21, no. 26 pp207-214

Air Pollution and Medical Care Costs

Raleigh=

$35 Million

extra Medicare costs

per year

Annual Asthma Costs

NC 7th & 8th Graders:

$14 million Hospitalizations

$ 1.4 million E.R. visits

All NC children:

$100 million Add M.D. visits, prescription costs, wages lost by parents who miss work, and costs for other children's age groups

NC Dept. HHS-Div. Of Public Health, 2001

Asthma in Buncombe County

~50%	Children in BC are on Medicaid
25-30%	Asthma symptoms (10% diagnosed)
$400,000	BCHD budget devoted to asthma care per year

NC Dept. HHS-Div. Of Public Health, 2001

Cost Shifting-We all pay

- Health care costs not paid by the auto, trucking, oil and electric utilities that generate pollution
- Private insurance premiums
- Lost school revenue for absences
- Federal taxes for Medicare (especially for the elderly)
- State taxes for Medicaid (especially for children and disabled)
- County taxes for BCHD
- Hospital and health care providers pass on the costs of the uninsured

Southeast Region

- 33,000,000 people living in significant air pollution
- 11,000 excess deaths yearly due to air pollution
- $20 billion in excess health care costs per year

SAMI Data Independent analysis

- EPA, NPS, USFS commissioned separate, more comprehensive (but still very limited) health impact assessment of SAMI data,
- **$11.5 billion to $44 billion annual health care savings in SE U.S. depending on degree of PM 2.5 reduction by 2010**

Impaired Visibility = Particulates

SAMI Data Independent analysis

$1 billion to $3 billion

annual recreation and tourism benefits lost due to air pollution and haze

5 Pieces to the Pollution Puzzle:

- Our Smokestacks
- Regional Smokestacks
- Vehicles
- Land Use and Transportation Planning—containing sprawl

5 Non-road engines—lawn, farm, marine, rail, construction, recreation and industrial

5 Pieces to the Pollution Puzzle:

- Our Smokestacks

Clean Smokestacks legislation

We are paying to clean up our power plants

Energy efficiency

5 Pieces to the Pollution Puzzle:

- Regional Smokestacks

Strengthen and enforce the Clean Air Act at the federal level

Negotiate with our neighboring states/TVA

Sue Thy Neighbor

5 Pieces to the Pollution Puzzle:

- Vehicles

Car purchase is the most important environmental decision you will make

Alternative fuel / hybrid cars

Convert vehicle fleets

Low sulfur fuel—statewide at all grades

Enforce diesel improvements/decrease truck stop idling

5 Pieces to the Pollution Puzzle:

- Land Use and Transportation Planning

More lanes=more sprawl (Atlanta)

Better “Transportation” solutions

Decrease Vehicle miles traveled

Mass Transit funding

Bikeways, sidewalks, greenways an integral part of the transport plan (obesity epidemic)

5 Pieces to the Pollution Puzzle:

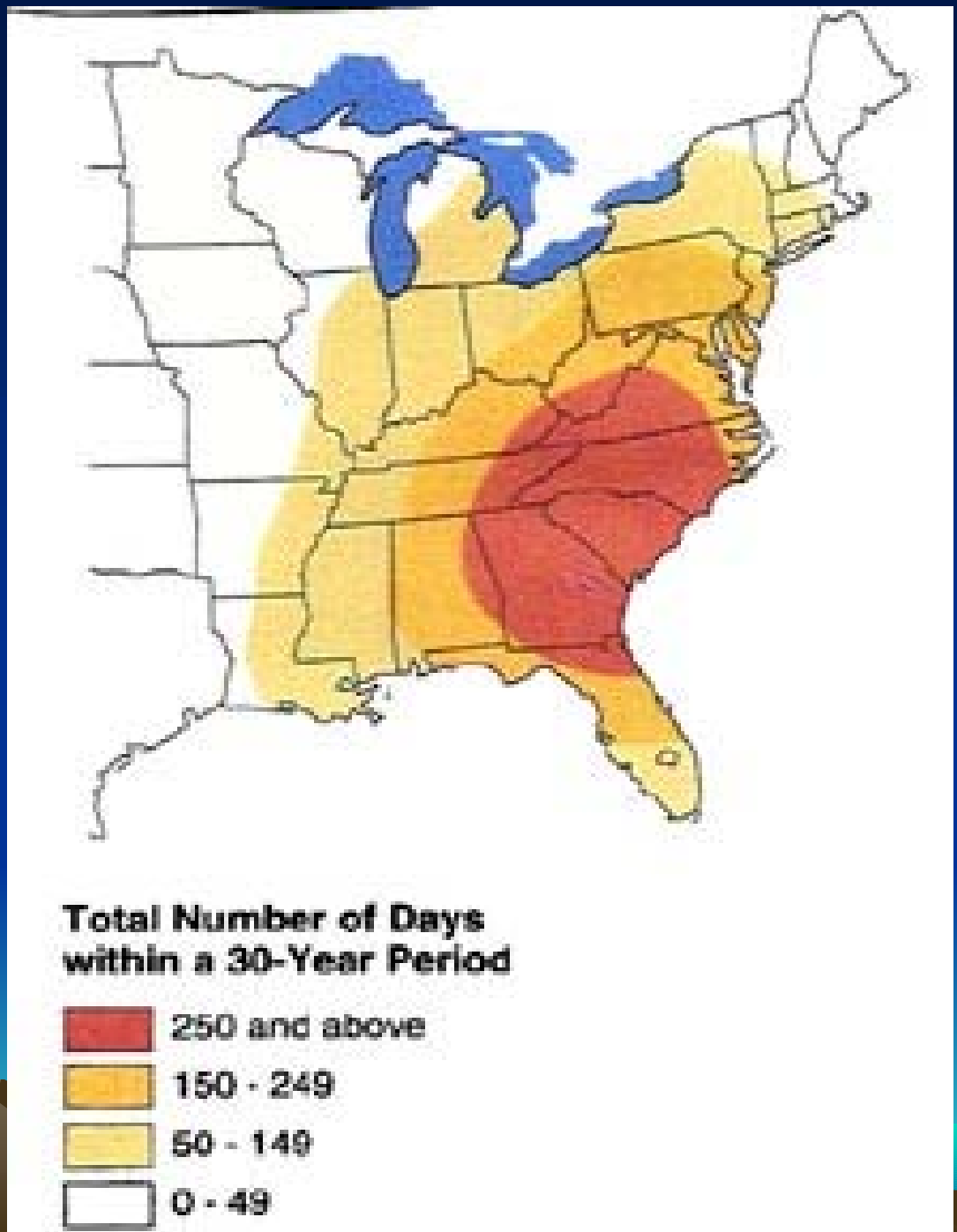
5 Non-road engines—lawn, farm, marine, rail, construction, recreation and industrial

Federal regulation of all forms of diesel and gas engines

Retrofit with catalytic converters

Final Points

- Prioritize air quality improvement in decision making
- Over half the problem is traffic
- Massive hidden health costs in transportation pollution
- Imposed risk on all population groups
- Basic research on highway design for minimizing pollution / mile and VMT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Web Sites

- www.lungusa.org (Annotated Bibliography of Recent Studies…)
- www.lungnc.org
- www.healtheffects.org (Understanding the Health Effects of Components of the Particulate Matter Mix: Progress and Next Steps)
- www.epa.gov/airnow
- www.nga.org
- www.landofsky.org/airquality
- www.cleartheair.org
- www.airtrust.org
- www.saminet.org